University of Sana'a
Faculty of Engineering
Department: Biomedical Engineering
Title of the Program: Biomedical Engineering

Course Specification of Biomedical Materials

Course Code (BE244)

I. Course Identification and General Information:						
1	**Course Title:**	Biomedical Materials				
2	**Course Code & Number:**	BE244				
3	**Credit hours:**	C.H				TOTAL
		Th.	Seminar	Pr	Tr.	
		2	--	--	2	3
4	**Study level/ semester at which this course is offered:**	3rd Level / 1st Semester				
5	**Pre –requisite (if any):**	BE101 & BE162				
6	**Co –requisite (if any):**	BE202				
7	**Program (s) in which the course is offered:**	Biomedical Engineering Program				
8	**Language of teaching the course:**	English				
9	**Location of Teaching the Course:**	Faculty of Engineering				
10	**Prepared by:**	Associate Prof. Dr. Khalil Al-Hatab				
11	**Reviewed by:**	Dr. ----				
12	**Date of Approval:**					

II. Course Description:

This course is designed to provide a fundamental knowledge of materials that are commonly utilized

in engineering and biomedical field specifically. Various types of materials currently being utilized for biomedical applications and their structures, properties and biocompatibility with references to the biological environments will be discussed.

III. Course Intended learning outcomes (CILOs) of the course (maximum 8CILOs)		**Referenced PILOs** (Only write code number of referenced Program Intended learning outcomes)
Knowledge and Understanding: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
a1	Describe the biocompatibility concept and the interdisciplinary issues involved in the design, synthesis, evaluation and analysis of biomaterials.	A1 Describe and explain the underlying mathematical methods and theories; life scientific-principles; and engineering core concepts related to the Biomedical Engineering context.
a2	Identify the different types of biomaterials and their structures, bulk and surface properties and phase diagrams.	A2 Clarify the design principles and techniques and the engineering materials characteristics and how these are relevant to the developments and technologies in a biomedical systems context.
a3	Understand the testing standards applied for biomaterials and their interactions with biological environment.	A4 Understand and give examples of design methods, knowledge tools, analytical skills, measurement techniques and methodologies for innovative and creative engineering solutions applied to healthcare problems and quality of life issues.
A. Cognitive/ Intellectual Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
b1	Propose the suitable materials for specific applications in biomedical systems and explain how to	B2 Identify, formulate and solve the complex problems related to the Biomedical

	overcome complexity of natural tissue structure that seek to replace with biomaterials.	Engineering fields in a creative and innovative manner by using a systematic and analytical thinking methods.
b2	Create combinations of materials that could be used as a tissue replacement implant.	B3 Design the biomedical systems or processes within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
C. Professional and Practical Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
c1	Integrate and apply life science and core science and engineering concepts to overcome challenges and further development in metallic, polymeric and ceramic materials.	C1 Apply integrally knowledge of mathematics, life science, IT, design, business context and engineering practice to solve problems and to design systems/processes relevant to Biomedical Engineering.
c2	Use standards testing procedures to evaluate the bulk and surface properties of materials.	C3 Use computational facilities and techniques, measuring instruments, workshops and laboratory equipment to design and conduct experiments, collect, analyse and interpret data and present results in the biomedical systems practice.
c3	List the main components of biomedical implants and justify the important characteristics of the implanted materials,	C4 Use rules and regulations of industrial safety as well as safe and diagnose systems at work, evaluate performance and observe the appropriate steps to manage risks concerning biomedical systems.
D. Transferable Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
d1	Engage in life-long self-learning to overcome challenges and further development in biomaterials.	D3 Recognize the needs for, and engage in life-long self-learning.

d2	Refer to relevant biomaterials resources that provide students with a greater familiarity with the biomaterials.	D4 Refer to relevant literatures, search for information, use databases, as well as, evaluate information and evidence from various sources in biomedical engineering.
d3	Interact and communicate effectively in both orally and writing forms.	D5 Demonstrate efficient IT capabilities and communicate effectively both orally and in writing technical reports.

(A) Alignment Course Intended Learning Outcomes of Knowledge and Understanding to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
a1. Describe the biocompatibility concept and the interdisciplinary issues involved in the design, synthesis, evaluation and analysis of biomaterials.	• Interactive lectures & examples, • Tutorials, • Interactive class discussions, • Case studies, • Exercises and home works, • Directed self- study, • Problem based learning,	• Written tests (mid and final terms and quizzes), • Coursework activities assessment, • Home works and assignments, • Presentations.
a2. Identify the different types of biomaterials and their structures, bulk and surface properties and phase diagrams.	• Interactive lectures & examples, • Tutorials, • Interactive class discussions, • Case studies, • Exercises and home works, • Directed self- study, • Problem based learning,	• Written tests (mid and final terms and quizzes), • Coursework activities assessment, • Home works and assignments, • Presentations.
a3. Understand the testing	• Interactive lectures &	• Written tests (mid and final

standards applied for biomaterials and their interactions with biological environment.	examples, • Tutorials, • Interactive class discussions, • Case studies, • Exercises and home works, • Directed self- study, • Problem based learning,	terms and quizzes), • Coursework activities assessment, • Home works and assignments, • Presentations.

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
b1. Propose the suitable materials for specific applications in biomedical systems and explain how to overcome complexity of natural tissue structure that seek to replace with biomaterials.	• Interactive lectures & examples, • Tutorials, • Presentation/seminar, • Interactive class discussions, • Case studies, • Exercises and home works, • Directed self- study, • Problem based learning,	• Written tests (mid and final terms and quizzes), • Coursework activities assessment, • Home works and assignments, • Presentations.
b2. Create combinations of materials that could be used as a tissue replacement implant	• Interactive lectures & examples, • Tutorials, • Presentation/seminar, • Interactive class discussions, • Case studies, • Exercises and home	• Written tests (mid and final terms and quizzes), • Coursework activities assessment, • Home works and assignments, • Presentations.

	works, • Directed self- study, • Problem based learning,	

(C) Alignment Course Intended Learning Outcomes of Professional and Practical Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
c1. Integrate and apply life science and core science and engineering concepts to overcome challenges and further development in metallic, polymeric and ceramic materials.	• Interactive lectures & examples, • Tutorials, • Presentation/seminar, • Interactive class discussions, • Case studies, • Exercises and home works, • Directed self- study, • Problem based learning,	• Written tests (mid and final terms and quizzes), • Coursework activities assessment, • Home works and assignments, • Presentations.
c2. Use standards testing procedures to evaluate the bulk and surface properties of materials.	• Interactive lectures & examples, • Tutorials, • Presentation/seminar, • Interactive class discussions, • Case studies, • Exercises and home works, • Directed self- study, • Problem based learning,	• Written tests (mid and final terms and quizzes), • Coursework activities assessment, • Home works and assignments, • Presentations.
c3. List the main components of biomedical implants and justify the important characteristics of the implanted materials.	• Interactive lectures & examples, • Tutorials, • Presentation/seminar,	• Written tests (mid and final terms and quizzes), • Coursework activities assessment, • Home works and

	• Interactive class discussions, • Case studies, • Exercises and home works, • Directed self- study, • Problem based learning,	assignments, • Presentations.

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1. Engage in life-long self-learning to overcome challenges and further development in biomaterials.	• Interactive lectures & examples, • Tutorials, • Presentation/seminar, • Interactive class discussions, • Case studies, • Exercises and home works, • Directed self- study, • Problem based learning,	• Written tests (mid and final terms and quizzes), • Coursework activities assessment, • Home works and assignments, • Presentations.
d2. Refer to relevant biomaterials resources that provide students with a greater familiarity with the biomaterials.	• Interactive lectures & examples, • Tutorials, • Presentation/seminar, • Interactive class discussions, • Case studies, • Exercises and home works, • Directed self- study, • Problem based learning,	• Written tests (mid and final terms and quizzes), • Coursework activities assessment, • Home works and assignments, • Presentations.
d3. Interact and communicate effectively in both orally and	• Interactive lectures & examples,	• Written tests (mid and final terms and

writing forms.	• Tutorials, • Presentation/seminar, • Interactive class discussions, • Case studies, • Exercises and home works, • Directed self- study, • Problem based learning,	quizzes), • Coursework activities assessment, • Home works and assignments, • Presentations.

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	contact hours
1	**Biomaterials Science and Engineering**	**a1,a2,a3, b2,d3**	– Course Overview – Materials Science and Engineering – Definitions of Biomaterials, Biomedical Materials, and Biological Materials, – Multilevel of Structure and Categorization of Materials – Four Categories of Materials, – Examples of Biomaterials Applications, – Advantages and Disadvantages of Biomaterials. – Definitions of Toxicology and Biocompatibility	**1**	**2**
2	**Structure of Materials**	**a1,a2,a3, b2,d3**	– Atomic Structure – Atomic Bonding – Crystal Structure of Metals, Ceramics and Polymers. – Defects in Solids – Diffusion in Solids.	**1**	**2**
3	**Bulk and**	**a1,a2,a3, b2,c2,d3,**	– Role of Implant Biomaterials	**1**	**2**

	Surface Properties of Materials		– Bulk Versus Surface – Mechanical Properties of General Importance – Bulk Mechanical Properties Determined From Stress–Strain Plots – Mechanical Properties Terms Used in the Medical Community – Failure – Other Bulk Properties – Surface Properties of Biomaterials – General Surface Considerations and Definitions – What Surface Properties Are We Interested in? – Surface Analysis Techniques: Principles and Methods		
4	**Phase Diagram**	**a1,a2,a3, b2,d3**	– Introduction to Phase Diagrams – Single Phase Diagram – Gibbs Phase Law – Lever Rule – Multiphase Materials Phase Diagrams, – Equilibrium Phase Transformation, – Microstructure Development	**1**	**2**
5	**Toxicity and Corrosion**	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3**	– Biological Roles and Toxicities of Trace Elements – Selection of Metallic Elements in Medical-Grade Alloys – Definition of Degradation, Erosion, Bulk, and Surface Processes – Biodegradation of Metals – Biodegradation of Ceramics – Degradable and Resorbable Polymers	**1**	**2**
6	**Metallic Biomaterials**	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3**	– Basic Principles and Concepts – Development of Metallic Biomaterials – Metallic Biomaterials in Orthopedic	**1**	**2**

			Implants – Stainless Steels – Cobalt-Based Alloys – Titanium Alloys – Dental Materials – NiTi Shape-Memory Alloys – Other Clinically Applied Metallic Materials – New Metallic Materials.		
7	**Ceramic Biomaterials**	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3**	– Basic Principles and Concepts – Overview of Bioceramics – Bioinert Ceramics – Bioactive and Bioresorbable Ceramics	**1**	**2**
8	**Mid-Term Theoretical Exam**	**a1,a2,a3, b1,b2,c1, c3,d1,d2, d3**	– All Preceding Lectures	**1**	**2**
9	**Polymeric Biomaterials**	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3**	– Basic Principles and Concepts – Overview and Classification of Polymeric Biomaterials – Bioinert Polymers – Bioresorbable Polymers – Hydrogels: Classification Basic Structures and Synthesis – Swelling Behavior of Hydrogels – Determination of Structural Characteristics – Biomedical Hydrogels – Smart Hydrogels and Their Applications – Biomedical Applications of Hydrogels	**2**	**4**
10	**Biomaterials-Tissue Interactions**	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3**	– Inflammation, – Wound Healing, – Foreign Body Reaction, – Blood Material Interaction	**1**	**2**

			– Tumorigenesis		
11	**Biological Testing of Biomaterials**	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3**	– In Vitro Test – In Vivo Test – Standard Testing Procedures	**1**	**2**
12	**Non-blood Interfacing Implant**	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3**	– Non-blood-interfacing Implants for Soft Tissue. – Choose Materials for The Implants. – Non-Blood-Interfacing Implant Characteristics	**1**	**2**
	Blood Contacting Implant	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3**	– Blood Contacting Implants. – Primary Requirements of Biomaterials for Blood Contacting Implant. – Choose Materials for the Implants. – Common Problems for Various Blood Contacting Implants	**1**	
13	**Hard Tissue Replacement**	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3**	– Types of Internal Fixation – Materials for the Fixations. – Failure Modes of Internal Fixation Devices – Types of Joint Replacements. – Types of Fixation Methods. – Choose Biomaterials for Each Component of Joint Replacements. – Types of Dental Implant – Dental Implant Materials	**1**	**2**
14	**Tissue Engineering and Scaffold**	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3**	– History, Scope and Potential of Tissue Engineering. – Tissue Engineering Development. – Properties of Scaffolds. – Scaffold Materials. – Scaffold Production Methods	**1**	**2**
15	**Final Theoretical**	**a1,a2,a3, b1,b2,c1,**	– All Preceding Lectures	**1**	**2**

	Exam	**c3,d3**			
Number of Weeks /and Units Per Semester				**16**	**32**

B - Practical Aspect: (if any)

Order	Tasks/ Experiments	Number of Weeks	contact hours	Learning Outcomes
1	**None**			
Number of Weeks /and Units Per Semester			**15**	**30**

C. Tutorial Aspect:

No.	Tutorial	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
1	**Tutorial 1:** Biomaterials Science and Engineering	1	2	**a1,a2,a3,b2, d1,d2, d3**
2	**Tutorial 2:** Structure of Materials	1	2	**a1,a2,a3,b2, d1,d2, d3**
3	**Tutorial 3:** Mechanical Properties of Materials	1	2	**a1,a2,a3,b2,c2, d1,d2, d3,**
4	**Tutorial 4:** Surface Properties of Materials	1	2	**a1,a2,a3,b2,c2, d1,d2, d3,**
5	**Tutorial 5:** Phase Diagram	1	2	**a1,a2,a3,b2,c2, d1,d2, d3,**
6	**Tutorial 6:** Metallic Biomaterials	1	2	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3,**
7	**Tutorial 7:** Ceramic Biomaterials	1	2	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3,**
8	**Tutorial 8:** Polymeric Biomaterials	1	2	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3,**

C. Tutorial Aspect:

No.	Tutorial	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
9	**Tutorial 9:** Biomaterials-Tissue Interactions	1	2	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3,**
10	**Tutorial 10:** Biological Testing of Biomaterials	1	2	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3,**
11	**Tutorial 11:** Non-blood Interfacing Implant	1	2	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3,**
12	**Tutorial 12:** Non-blood Interfacing Implant	1	2	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3,**
13	**Tutorial 13:** Blood Contacting Implant	1	2	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3,**
14	**Tutorial 14:** Hard Tissue Replacement	2	4	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3,**
15	**Tutorial 15:** Tissue Engineering and Scaffold	1	2	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3,**
Number of Weeks /and Units Per Semester		**15**	**30**	

V. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Tutorials,
- Presentation/seminar,
- Interactive class discussions,
- Case studies,
- Exercises and home works,
- Directed self- study,
- Problem based learning,

VI. Assessment Methods of the Course:

- Written tests (mid and final terms and quizzes),
- Coursework activities assessment,
- Home works and assignments,
- Presentations.

VII. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1	**Tutorials: # 15**	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3**	Weekly	30
Total				30

VIII. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
1	**Assignments**	**Weekly**	**30**	**20%**	**a1,a2,a3, b1,b2,c1, c2,c3,d1, d2,d3**
2	**Quizzes**	**5 & 10**	**20**	**13.3**	**a1,a2,a3, b1,b2,c1, c3,d3**
3	**Midterm Theoretical Exam**	**8**	**30**	**20%**	**a1,a2,a3, b1,b2,c1, c3,d3**
4	**Final Theoretical Exam**	**16**	**70**	**46.7%**	**a1,a2,a3, b1,b2,c1, c3,d3**
Total			150	100%	

IX. Learning Resources:

1- Required Textbook(s) (maximum two).

1. Qizhi Chen and George Thouas, 2015, **Biomaterials: A Basic Introduction**, 1st Edition, USA, CRC Press.
2. Callister W.D., 2008, **Fundamentals of Materials Science and Engineering: An Integrated Approach**, 3rd Edition, USA, John Wiley.

2- Essential References.

1. J.S Temenoff and A.G. Mikos. 2008, **Biomaterials: The intersection of Biology and Material Science**, USA, Pearson Prentice Hall.
2. Buddy D. Ratner, Allon S. Hoffman, Frederick J. Schoen, Jack E. Lemons, 2013, **Biomaterials Science An Introduction to Materials in Medicine**, 3rd Edition, USA, Elsevier Academic Press.
3. Park, J. B.; Lakes R. S., 2007, **Biomaterials: An Introduction**, 3rd Edition, , New York, Plenum Press.
4. Sujata V. Bhatt, 2005, **Biomaterials**, 2nd Edition, Narosa Publishing House,.
5. Sreeram Ramakrishna, Murugan Ramalingam, T. S. Sampath Kumar, and Winston O. Soboyejo, 2010, **Biomaterials: A Nano Approach**, 1st Edition, USA, CRC Press, 2010
6. Myer Kutz, 2003, **Standard Handbook of Biomedical Engineering & Design**, McGraw Hill,
7. John Enderle, Joseph D. Bronzino, Susan M.Blanchard, 2005, **Introduction to Biomedical Engineering**, Elsevier, 2005.
8. Park J.B., 1984, **Biomaterials Science and Engineering**, Plenum Press..

3- Electronic Materials and Web Sites *etc*.

Websites:

Biomaterials Journals

1. Advanced Drug Delivery Reviews (Elsevier)
2. American Society of Artificial Internal Organs Transactions
3. Annals of Biomedical Engineering (Blackwell—Official Publication of the Biomedical Engineering Society)
4. Artificial Organs (Raven Press)
5. Biomaterials, Artificial Cells and Artificial Organs (T. M.S. Chang, ed.)
6. Biomaterials forum (Society For Biomaterials)
7. Biomatenals: Processing, Testing and Manufacturing Technology (Butterworth)

	8. Biomedical Materials (Elsevier)

X. Course Policies:

1	**Class Attendance:** A student should attend not less than 75 % of total hours of the subject; otherwise he/she will not be able to take the exam and will be considered as exam failure. If the student is absent due to illness, he/she should bring a proof statement from university Clinic. If the absent is more than 25% of a course total contact hours, student will be required to retake the entire course again.
2	**Tardy:** For late in attending the class, the student will be initially notified. If he repeated lateness in attending class, he/she will be considered as absent.
3	**Exam Attendance/Punctuality:** A student should attend the exam on time. He/she is permitted to attend an exam half one hour from exam beginning, after that he/she will not be permitted to take the exam and he/she will be considered as absent in exam
4	**Assignments & Projects:** In general one assignment is given to the students after each chapter; the student has to submit all the assignments for checking on time, mostly one week after given the assignment.
5	**Cheating:** For cheating in exam, a student will be considered as fail. In case the cheating is repeated three times during his/her study the student will be disengaged from the Faculty.
6	**Plagiarism:** Plagiarism is the attending of a student the exam of a course instead of another student. If the examination committee proofed a plagiarism of a student, he/she will be disengaged from the Faculty. The final disengagement of the student from the Faculty should be

	confirmed from the Student Council Affair of the university or according to the university roles.
7	**Other policies**: - Mobile phones are not allowed to use during a class lecture. It must be closed; **otherwise** the student will be asked to leave the lecture room. - Mobile phones are not allowed in class during the examination. - Lecture notes and assignments might be given directly to students using soft or hard copy.

University of Sana'a
Faculty of Engineering
Department: Biomedical Engineering
Title of the Program: Biomedical Engineering

Template for Course Plan (Syllabus)

Biomedical Materials
BE244

I. Course Identification and General Information:					
1	**Course Title:**	Biomedical Materials			
2	**Course Code & Number:**	BE244			
3	**Credit Hours:**	**Credit Hours**	**Theory Hours**		**Lab. Hours**
			Lecture	**Exercise**	
		3	2	2	--
4	**Study Level/ Semester at which this Course is offered:**	3rd Level / 1st Semester			
5	**Pre –Requisite (if any):**	BE101 & BE162			
6	**Co –Requisite (if any):**	BE202			
7	**Program (s) in which the Course is Offered:**	Biomedical Engineering Program			
8	**Language of Teaching the Course:**	English			
9	**Location of Teaching the Course:**	Faculty of Engineering			
10	**Prepared by:**	Associate Prof. Dr. Khalil Al-Hatab			
11	**Reviewed by:**	Dr. ----			
12	**Date of Approval:**				

II. Course Description:

This course is designed to provide a fundamental knowledge of materials that are commonly utilized in engineering and biomedical field specifically. Various types of materials currently being utilized

for biomedical applications and their structures, properties and biocompatibility with references to the biological environments will be discussed.

III. Course Intended Learning Outcomes (CILOs): (مخرجات تعلم المقرر)	
A. Knowledge and Understanding: Upon successful completion of the course, students will be able to:	
a1	Describe the biocompatibility concept and the interdisciplinary issues involved in the design, synthesis, evaluation and analysis of biomaterials.
a2	Identify the different types of biomaterials and their structures, bulk and surface properties and phase diagrams.
a3	Understand the testing standards applied for biomaterials and their interactions with biological environment.
B. Intellectual Skills: Upon successful completion of the course, students will be able to:	
b1	Propose the suitable materials for specific applications in biomedical systems and explain how to overcome complexity of natural tissue structure that seek to replace with biomaterials.
b2	Create combinations of materials that could be used as a tissue replacement implant
C. Professional and Practical Skills: Upon successful completion of the course, students will be able to:	
c1	Integrate and apply life science and core science and engineering concepts to overcome challenges and further development in metallic, polymeric and ceramic materials.
c2	Use standards testing procedures to evaluate the bulk and surface properties of materials.
c3	List the main components of biomedical implants and justify the important characteristics of the implanted materials.
D. Transferable Skills: Upon successful completion of the course, students will be able to:	
d1	Engage in life-long self-learning to overcome challenges and further development in biomaterials.
d2	Refer to relevant biomaterials resources that provide students with a greater familiarity with the biomaterials.
d3	Interact and communicate effectively in both orally and writing forms.

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
1	**Biomaterials Science and Engineering**	– Course Overview – Materials Science and Engineering – Definitions of Biomaterials, Biomedical Materials, and Biological Materials, – Multilevel of Structure and Categorization of Materials – Four Categories of Materials, – Examples of Biomaterials Applications, – Advantages and Disadvantages of Biomaterials. – Definitions of Toxicology and Biocompatibility	**1**	**2**
2	**Structure of Materials**	– Atomic Structure – Atomic Bonding – Crystal Structure of Metals, Ceramics and Polymers. – Defects in Solids – Diffusion in Solids.	**1**	**2**
3	**Bulk and Surface Properties of Materials**	– Role of Implant Biomaterials – Bulk Versus Surface – Mechanical Properties of General Importance – Bulk Mechanical Properties Determined From Stress–Strain Plots – Mechanical Properties Terms Used in the Medical Community – Failure – Other Bulk Properties – Surface Properties of Biomaterials	**1**	**2**

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		– General Surface Considerations and Definitions – What Surface Properties Are We Interested in? – Surface Analysis Techniques: Principles and Methods		
4	**Phase Diagram**	– Introduction to Phase Diagrams – Single Phase Diagram – Gibbs Phase Law – Lever Rule – Multiphase Materials Phase Diagrams, – Equilibrium Phase Transformation, – Microstructure Development	**1**	**2**
5	**Toxicity and Corrosion**	– Biological Roles and Toxicities of Trace Elements – Selection of Metallic Elements in Medical-Grade Alloys – Definition of Degradation, Erosion, Bulk, and Surface Processes – Biodegradation of Metals – Biodegradation of Ceramics – Degradable and Resorbable Polymers	**1**	**2**
6	**Metallic Biomaterials**	– Basic Principles and Concepts – Development of Metallic Biomaterials – Metallic Biomaterials in Orthopedic Implants – Stainless Steels – Cobalt-Based Alloys – Titanium Alloys – Dental Materials	**1**	**2**

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		– NiTi Shape-Memory Alloys – Other Clinically Applied Metallic Materials – New Metallic Materials.		
7	**Ceramic Biomaterials**	– Basic Principles and Concepts – Overview of Bioceramics – Bioinert Ceramics – Bioactive and Bioresorbable Ceramics	**1**	**2**
8	**Mid-Term Theoretical Exam**	– All Preceding Lectures	**1**	**2**
9	**Polymeric Biomaterials**	– Basic Principles and Concepts – Overview and Classification of Polymeric Biomaterials – Bioinert Polymers – Bioresorbable Polymers – Hydrogels: Classification Basic Structures and Synthesis – Swelling Behavior of Hydrogels – Determination of Structural Characteristics – Biomedical Hydrogels – Smart Hydrogels and Their Applications – Biomedical Applications of Hydrogels	**2**	**4**
10	**Biomaterials-Tissue Interactions**	– Inflammation, – Wound Healing, – Foreign Body Reaction, – Blood Material Interaction – Tumorigenesis	**1**	**2**

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
11	**Biological Testing of Biomaterials**	– In Vitro Test – In Vivo Test Tissue – Standard Testing Procedures	**1**	**2**
12	**Non-blood Interfacing Implant**	– Non-blood-interfacing Implants for Soft Tissue. – Choose Materials for The Implants. – Non-Blood-Interfacing Implant Characteristics	**1**	**2**
13	**Blood Contacting Implant**	– Blood Contacting Implants. – Primary Requirements of Biomaterials for Blood Contacting Implant. – Choose Materials for the Implants. – Common Problems for Various Blood Contacting Implants	**1**	**2**
14	**Hard Tissue Replacement**	– Types of Internal Fixation – Materials for the Fixations. – Failure Modes of Internal Fixation Devices – Types of Joint Replacements. – Types of Fixation Methods. – Choose Biomaterials for Each Component of Joint Replacements. – Types of Dental Implant – Dental Implant Materials	**1**	**2**
15	**Tissue Engineering and Scaffold**	– History, Scope and Potential of Tissue Engineering. – Tissue Engineering Development. – Properties of Scaffolds. – Scaffold Materials.	**1**	**2**

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		– Scaffold Production Methods		
16	**Final Theoretical Exam**	– All Preceding Lectures	**1**	**2**
Number of Weeks /and Units Per Semester			**16**	**32**

B. Case Studies and Practical Aspect:

No.	Tasks/ Experiments	Number of Weeks	Contact Hours
1	None		
Number of Weeks /and Units Per Semester		**15**	**30**

C. Tutorial Aspect:

No.	Tutorial	Number of Weeks	Contact Hours
1	**Tutorial 1:** Introduction and Structure of Materials	1	2
2	**Tutorial 2:** Structure of Materials	1	2
3	**Tutorial 3:** Mechanical Properties of Materials	1	2
4	**Tutorial 4:** Surface Properties of Materials	1	2
5	**Tutorial 5:** Phase Diagram	1	2
6	**Tutorial 6:** Metallic Biomaterials	1	2
7	**Tutorial 7:** Ceramic Biomaterials	1	2
8	**Tutorial 8:** Polymeric Biomaterials	1	2
9	**Tutorial 9:** Biomaterials-Tissue Interactions	1	2

C. Tutorial Aspect:			
No.	**Tutorial**	**Number of Weeks**	**Contact Hours**
10	**Tutorial 10:** Biological Testing of Biomaterials	1	2
11	**Tutorial 11:** Non-blood Interfacing Implant	1	2
12	**Tutorial 12:** Non-blood Interfacing Implant	1	2
13	**Tutorial 13:** Blood Contacting Implant	1	2
14	**Tutorial 14:** Hard Tissue Replacement	2	4
15	**Tutorial 15:** Tissue Engineering and Scaffold	1	2
Number of Weeks /and Units Per Semester		**15**	**30**

V. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Tutorials,
- Presentation/seminar,
- Interactive class discussions,
- Case studies,
- Exercises and home works,
- Directed self- study,
- Problem based learning,

VI. Assessment Methods of the Course:

- Written tests (mid and final terms and quizzes),
- Coursework activities assessment,
- Home works and assignments,
- Presentations.

VII. Assignments:

No.	Assignments	Week Due	Mark
1	**Tutorials: # 15**	Weekly	30
Total			

VIII. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment
1	**Assignments**	**Weekly**	**30**	**20%**
2	**Quizzes**	**5 & 10**	**20**	**13.3**
3	**Midterm Theoretical Exam**	**8**	**30**	**20%**
4	**Final Theoretical Exam**	**16**	**70**	**46.7%**
Total			**150**	**100%**

IX. Learning Resources:

1- Required Textbook(s) (maximum two):

1. Qizhi Chen and George Thouas, 2015, **Biomaterials: A Basic Introduction**, 1st Edition, USA, CRC Press.
2. Callister W.D., 2008, **Fundamentals of Materials Science and Engineering: An Integrated Approach**, 3rd Edition, USA, John Wiley.

2- Essential References:

1. J.S Temenoff and A.G. Mikos. 2008, **Biomaterials: The intersection of Biology and Material Science**, USA, Pearson Prentice Hall.
2. Buddy D. Ratner, Allon S. Hoffman, Frederick J. Schoen, Jack E. Lemons, 2013, **Biomaterials Science An Introduction to Materials in Medicine**, 3rd Edition, USA, Elsevier Academic Press.
3. Park, J. B.; Lakes R. S., 2007, **Biomaterials: An Introduction**, 3rd Edition, , New York, Plenum Press.

IX. Learning Resources:

4. Sujata V. Bhatt, 2005, **Biomaterials**, 2nd Edition, Narosa Publishing House,.
5. Sreeram Ramakrishna, Murugan Ramalingam, T. S. Sampath Kumar, and Winston O. Soboyejo, 2010, **Biomaterials: A Nano Approach**, 1st Edition, USA, CRC Press, 2010
6. Myer Kutz, 2003, **Standard Handbook of Biomedical Engineering & Design**, McGraw Hill,
7. John Enderle, Joseph D. Bronzino, Susan M.Blanchard, 2005, **Introduction to Biomedical Engineering**, Elsevier, 2005.
8. Park J.B., 1984, **Biomaterials Science and Engineering**, Plenum Press..

3- Electronic Materials and Web Sites etc.:

Websites:

Biomaterials Journals

1. Advanced Drug Delivery Reviews (Elsevier)
2. American Society of Artificial Internal Organs Transactions
3. Annals of Biomedical Engineering (Blackwell—Official Publication of the Biomedical Engineering Society)
4. Artificial Organs (Raven Press)
5. Biomaterials, Artificial Cells and Artificial Organs (T. M.S. Chang, ed.)
6. Biomaterials forum (Society For Biomaterials)
7. Biorationals: Processing, Testing and Manufacturing Technology (Butterworth)
8. Biomedical Materials (Elsevier)

X. Course Policies:

1	**Class Attendance:** A student should attend not less than 75 % of total hours of the subject; otherwise he/she will not be able to take the exam and will be considered as exam failure. If the student is absent due to illness, he/she should bring a proof statement from university Clinic. If the absent is more than 25% of a course total contact hours, student will be required to retake the entire course again.
2	**Tardy:** For late in attending the class, the student will be initially notified. If he repeated lateness in

	attending class, he/she will be considered as absent.
3	**Exam Attendance/Punctuality:** A student should attend the exam on time. He/she is permitted to attend an exam half one hour from exam beginning, after that he/she will not be permitted to take the exam and he/she will be considered as absent in exam
4	**Assignments & Projects**: In general one assignment is given to the students after each chapter; the student has to submit all the assignments for checking on time, mostly one week after given the assignment.
5	**Cheating**: For cheating in exam, a student will be considered as fail. In case the cheating is repeated three times during his/her study the student will be disengaged from the Faculty.
6	**Plagiarism**: Plagiarism is the attending of a student the exam of a course instead of another student. If the examination committee proofed a plagiarism of a student, he/she will be disengaged from the Faculty. The final disengagement of the student from the Faculty should be confirmed from the Student Council Affair of the university or according to the university roles.
7	**Other policies**: - Mobile phones are not allowed to use during a class lecture. It must be closed; **otherwise** the student will be asked to leave the lecture room. - Mobile phones are not allowed in class during the examination. - Lecture notes and assignments might be given directly to students using soft or hard copy.